

**APPLICATION FOR UNITED STATES  
LETTERS PATENT**

**SPIRAL PLEATED ROLLER BOTTLE**

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## **RELATED APPLICATIONS**

[0001] This application claims priority from U.S. Provisional Patent Application Serial No. 60/505,742 filed on September 25, 2003, and from U.S. Provisional Patent 5 Application Serial No. 60/437,748, filed on January 2, 2003.

## **BACKGROUND OF THE INVENTION**

### **1. Field of the Invention**

[0002] This invention relates to a container for cell culture production, and, more particularly, to a roller bottle having at least one angled exterior pleat for achieving a high cell growth surface area on the interior of the bottle and for facilitating access to all surface areas by liquids deposited in the bottle.

### **2. Description of the Related Art**

[0003] One type of container commonly used in laboratories for culturing cells is known as a "roller bottle". Roller bottles are generally cylindrical and are adapted to rotate about their vertical axes. The internal surfaces of such roller bottles provide active regions for culturing cells. A liquid growth medium is introduced into the roller bottle. The rotating movement of the bottle keeps the internal surfaces wetted with the liquid medium, thereby encouraging the growth of cells.

[0004] Rotating rollers of an appropriate apparatus rotate these roller bottles. It is desirable to grow large amounts of cells, mostly for cell by-products, such as pharmaceutical substances that are secreted by cells. Various approaches have been used to increase the internal surface area of roller bottles. One approach has been to

5 increase the amount of actual surface area available for cell growth.

[0005] Some roller bottles are produced unitarily by a blow-molding technique and include longitudinal pleats in the walls of the roller bottle. The longitudinal pleats increase the effective internal surface area of the roller bottle, and extend into the growth chamber for increasing culture or cell yield.

10 [0006] It is further known to provide a culture vessel having such longitudinal pleats, and further including circumferential collars that encircle the external surface of the top and bottom ends of the vessel. The collars maximize the vessel's grip point when the vessel is placed on its side on the rollers of a rotating apparatus such as a roller rack.

15 [0007] The prior art also discloses a roller bottle having pleats perpendicular to the longitudinal axis of the bottle for increasing the surface area for growing cells and further including at least one unpleated longitudinal drain panel. Reinforcing ribs on the exterior of the bottle parallel to the longitudinal axis of the bottle extend along the outer edge of the cross-wise corrugation for strengthening the pleated bottle.

20 [0008] It is also known to use circumferential ribs on a roller bottle for reinforcing the bottle walls. In this regard, the prior art discloses a roller bottle having flexible

plastic walls and a plurality of spaced-apart circumferential reinforcement rings defined in the flexible plastic walls to cause the body to retain a generally cylindrical shape.

[0009] A problem associated with prior art roller bottles, especially those having pleats for expanding the surface area for growing cells, has been the tendency of the 5 bottle walls to expand when the insides of the bottles become pressurized. This expansion causes the bottle to stop rolling on a roller rack. The absence of rotation causes portions of the surfaces to become dry and promotes cell death in these dry areas.

[0010] Another problem associated with prior art roller bottles relates to the ability 10 to assure that liquid placed in the roller bottle will achieve maximum contact with all interior surface regions of the pleated walls. In this regard, it has been determined that roller bottles with circumferential pleats will distribute liquid efficiently within any given pleat as the roller bottle is rotated about its axis. However, liquid may not be distributed uniformly among the various circumferential pleats. Although longitudinal pleats allow 15 liquid to flow longitudinally along the grooves defined by the pleats, rotation of such a longitudinal-pleated roller bottle about its longitudinal axis does not always distribute liquid efficiently from one longitudinal pleat to another, and also results in increased agitation of the liquid, which is detrimental to cell growth and cultivation.

[0011] It is desirable therefore to provide a pleated roller bottle which safeguards 20 against bottle expansion under pressure to thereby allow the roller bottle to continue rolling on a roller rack.

[0012] It is also desirable to provide roller bottles with a pleat arrangement that permits efficient flow of liquid to all surface areas defined by the pleats while maintaining agitation of the liquid.

## SUMMARY OF THE INVENTION

**[0013]** The present invention provides a roller bottle for cell growth culturing including an elongate cylindrical side wall, a closed bottom end and an opening at an opposing top end. The elongate cylindrical wall includes at least one helical or spiral 5 pleat that extends from proximate the top end to proximate the bottom end. The elongate cylindrical side wall may further include a longitudinal smooth surface or two diametrically opposed longitudinal smooth surfaces that run the length of the bottle.

**[0014]** The spiral or helical pleat provides an advantage over circumferential pleats when cells are harvested from the bottle. In particular, cells are collected from 10 the bottle by first pouring off the liquid growth medium and then detaching the cells from the bottle walls. Frequently, a trypsin solution is poured into the bottle and then distributed around the inside of the bottle to cover all of the cells. A continuous helical or spiral pleat path running substantially the entire length of the bottle enables the trypsin to more easily reach all of the cells because the trypsin can follow a continuous 15 path around the pleat as the bottle is rotated about its axis. In contrast, circumferential pleats or longitudinal pleats may complicate uniform distribution of trypsin to all areas of the bottle from which cells may be harvested. Thus, a much more thorough coating with trypsin is achieved with a spiral or helical pleat.

**[0015]** Other objects and features of the present invention will become apparent 20 from the following detailed description considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are designed solely for purposes of illustration and not as a definition of the limits of the invention. It should be

further understood that the drawings are not necessarily drawn to scale and that, unless otherwise indicated, they are merely intended to conceptually illustrate the structures and procedures described herein.

## **BRIEF DESCRIPTION OF THE DRAWINGS**

**[0016]** In the drawings wherein like reference characters denote similar elements throughout the several views:

**[0017]** FIG. 1 is a side elevational view of a roller bottle in accordance with the 5 present invention;

**[0018]** FIG. 2 is a side elevational view of a roller bottle in accordance with a secondary version of the present invention;

**[0019]** FIG. 3 is a horizontal sectional view of the roller bottle of FIG. 1 taken along line 3-3 of FIG. 1; and

10 **[0020]** FIG. 4 is a cross-sectional view of the roller bottle of FIG. 1 taken along line 4-4 in FIG. 3.

## DETAILED DESCRIPTION OF THE INVENTION

[0021] A roller bottle 10 in accordance with the present invention is shown in FIGs. 1-4. Roller bottle 10 includes a generally cylindrical side wall 12 which extends between proximate a top wall 16 and proximate a bottom wall 14. Extending from top 5 wall 16 and integral therewith is a neck 18 having extended screw threads 20 for receiving an internally threaded screw cap (not shown) thereon in the usual manner. Other cap connections, such as bayonet connections, may be used. Neck 18 may include a locking arrangement 22 for holding a cap in a locked open position on the roller bottle for maintaining the roller bottle open to the environment.

10 [0022] As described above, a problem associated with prior art roller bottles that have longitudinal pleats is that the pleats tend to expand when the inside of the bottle becomes pressurized. This may occur when the roller bottle is sealed and warmed in an incubator, resulting in an elevation of the internal bottle pressure, typically by about 0.069 BAR (1 psi). The internal pressure in the roller bottle may cause the walls to bow 15 outward which causes the bottle to stop rolling on the roller rack. As a result, portions of the interior surface of the bottle become dry while other portions of the interior surface of the bottle stay immersed, leading to cell death and a reduction in culture yield.

[0023] Roller bottle 10 addresses the problem of side wall expansion by providing at least one helical or spiral pleat 24 arranged on the surface of the bottle at an offset 20 angle with respect to the longitudinal axis of the bottle 10. Pleats 24 are, thus, arranged in a substantially "spiral" or helical layout about the bottle side wall 12. Preferably, pleats 24 extend between a vertical location substantially below and proximate to top

wall 16, and a vertical location substantially above and proximate to bottom wall 14, i.e., about 0.6 cm (0.25 inches) from the top and bottom, respectively.

**[0024]** In accordance with the invention, the pleat can take the form of a single helical spiral (pleat 24a in FIG. 2) which runs between the top and bottom of bottle 10.

5 In this case, the single spiral has a very shallow angle “ $\theta$ ” with respect to a plane cutting perpendicularly through the longitudinal axis 25 of bottle 10 (a “horizontal axis”), for example in the range of from about 2° to about 10°. As the angle of pleat 24 increases with respect to the horizontal axis, the width of pleat 24 should be increased, otherwise a “blank” spot between adjacent turns of the pleat will exist. Preferably, additional 10 pleats 24 should be added to maximize the surface coverage of bottle 10 and provide sufficient cell cultivation area as shown in of FIG. 1.

**[0025]** As seen in FIG. 1, each pleat 24 is oriented at an angular pitch “ $\alpha$ ” relative to the horizontal axis of the bottle 10, wherein angle “ $\alpha$ ” ranges between 45° and 70° with respect to the horizontal axis, and is at about 65°.

15 **[0026]** Spiral pleats 24 provide a reinforcing effect similar to the circumferential pleats of the prior art. As can be seen in FIGs. 3 and 4, pleats 24 provide a plurality of opposed facing internal surfaces 26 for the formation of cell growth. Thus, the pleated structure increases the internal active surface area of roller bottle 10 while safeguarding against deformation of the bottle when pressurized to prevent cessation of bottle 20 rotation on a roller rack.

**[0027]** While the present invention may be constructed in various sizes and configurations, the structure of the present roller bottle includes a bottle which is

approximately 27.08 cm (10.66 inches) in length from the top of neck **18** to the bottom of base **14**. Such a configured bottle defines a growth surface area length of about 22.86 cm (9.0 inches) having a diameter of about 11.76 cm (4.63 inches). As shown in FIG. 4, the internal surfaces **26** formed by the pleats **24** represent a generally wave-like structure having outer and inner apices **28** and **30**, respectively. Outer apices **28** extend to a circumference **38** (see FIG. 3). Inner apices **30** form interior channels on the inner surface of bottle **10**, thereby permitting laminar flow of the liquid growth medium therethrough. The period defined between adjacent outer apices **28** is approximately 0.05 cm (0.195 inches). Opposing or facing internal surfaces **26** (shown 5 as surfaces **32** and **34**) of adjacent spiral pleats **24** define an angle “ $\beta$ ”, which may be approximately 42°. Inner apices **30** of pleats **24** are desirably rounded to facilitate cell adherence to internal surfaces **26**. Moreover, such rounded surfaces are easy to form 10 by casing or molding and are stronger and less subject to cracking if flexed.

**[0028]** As shown in FIGs. 1-3, roller bottle **10** may further include diametrically 15 opposed longitudinally extending smooth sections, or lands, **36** that interrupt pleats **24** to enhance the microscopic viewing of the contents of roller bottle **10** and/or to facilitate culturing of cells. In various embodiments of the present invention, the roller bottle contains two diametrically opposed smooth sections **36** to facilitate microscopic viewing. The particular arrangement of smooth sections **36** shown in the drawings is not critical. 20 Moreover, the width of smooth sections **36** is not critical, except that these panels also decrease the amount of internal surfaces **26** which are used for cell growth. Each smooth section **36** may be between about 5.715 cm (2.25 inches) and about 7.62 cm (3

inches) in length, measured circumferentially. Pleats **24** are approximately 0.02 cm (0.079 inches) deep, when measured radially from circumference **38**.

[0029] It is noted that roller bottle **10** may include a recessed portion (not shown) in bottom wall **14** to facilitate stacking of roller bottle **10** with a similar bottle in a nesting 5 relationship.

[0030] The spirally pleated roller bottle **10** of the present invention can be used to increase the culture or cell yields per unit for either adherent-type cells or cells that grow in suspension. It is noted that adherent-type cells include cells which require a support surface to grow on, as well as cells capable of growing on a support surface. By the 10 phrase "increase the culture or cell yields", it is meant that there is an increase in the number of cells and/or their by-products per culture vessel or unit. As shown in the drawings herein, cylindrical side wall **12** of roller bottle **10** has a plurality of spiral pleats **24** (shown in FIG. 1) or a plurality of turns of a single spiral pleat **24a** as in FIG. 2, along a substantial portion of the length of the bottle, thus corrugating interior surfaces **26**. 15 The interior pleating increases the surface area available for the attachment and growth of adherent-type cells, thus increasing the culture or cell yields per vessel.

[0031] After cells have formed on internal surfaces **26** of roller bottle **10** by rolling the bottle in the proper environment for the formation of the cells, roller bottle **10** with 20 formed cells on the walls thereof is removed from a roller rack. The cell forming liquid medium remaining in bottle **10** may be decanted from bottle **10** along pleats **24** and smooth sections **32**. A small amount of saline solution may be added to wash the cells

of lingering medium components. Alternatively, the liquid medium may remain in the bottle if it is only present in a small amount.

[0032] A more conventional procedure for removing cells is by introducing a solution containing the proteolytic enzyme trypsin, together with a chelating agent, 5 which has the effect of causing the cells to release from internal surfaces **26** for decanting from roller bottle **10** along spiral pleats **24** and longitudinal smooth sections **32**. More particularly, spiral pleats **24** ensure that the trypsin solution follows the spiral paths formed by pleats **24** from the top end **16** to the bottom end **14** of the bottle **10** merely by rotating bottle **10** about its longitudinal axis **36**. Hence, complete exposure to 10 the trypsin solution is assured, thereby maximizing cell yield. Subsequently, roller bottle **10** may be discarded.

[0033] Thus, the advantage of providing a roller bottle **10**, such as that of the present invention, which may be inexpensively produced by blow-molding, used once, and then discarded, is readily apparent. The inventive roller bottle **10** provides a unitary 15 structure including an elongate cylindrical wall with spiral pleats that provide a greatly increased surface area for cell growth formation. The spiral pleats on the cylindrical wall further reinforce the bottle walls and eliminate the need to discard the roller bottle prematurely during culturing due to repeated flexing of the pleats which can cause fatigue and cause the bottle to stop rolling on the roller rack, especially during long 20 periods of use in connection with a cell culturing batch process. Spiral pleats **24** reinforce the structure of roller bottle **10** and prevent the bending and extension of side wall **12**.

[0034] In viewing generally the conditions for producing roller bottles in accordance with the invention, a variety of thermoplastic materials may be utilized including, for example polystyrene, polyethylene terephthalate, the polyolefins and polyvinyl chloride. Polystyrene is particularly desirable as cells appear to grow well and 5 in large numbers on this material.

[0035] The wall of the bottle should have a sufficient thickness to provide a bottle with adequate strength when filled with a liquid. Typically, the material used for forming the bottle should have a thickness of about 0.0236 inches (0.06 cm) for a 2.25 liter roller bottle. The thermoplastic resin used for forming bottles by extrusion, blow or injection 10 blow-molding techniques should be able to readily flow to form the spiral pleats.

[0036] It is noted that various embodiments of the invention have been described and that numerous substitutions, modifications and alterations are permissible without departing from the spirit and scope of the invention. For example, a cross-hatched pattern of intersecting spiral pleats could be used. Moreover, a bottle having flat side wall 15 sections approximating a cylinder, e.g., an octagon-shaped horizontal cross-section, can be employed instead of the cylindrical bottles depicted in the figures. The design must be such that the bottle is not hindered from rolling on its vertical axis when placed on a rolling apparatus.

[0037] It will be understood that various omissions and substitutions and changes 20 in the form and details of the devices illustrated, and in their operation, may be made by those skilled in the art without departing from the spirit of the invention. For example, it is expressly intended that all combinations of those elements which perform

substantially the same function in substantially the same way to achieve the same results are within the scope of the invention. Moreover, it should be recognized that structures and/or elements shown and/or described in connection with any disclosed form or embodiment of the invention may be incorporated in any other disclosed or

5 described or suggested form or embodiment as a general matter of design choice.